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Industrial Commission of Wisconsin

Shop lighting

[Madison?]

[1914]

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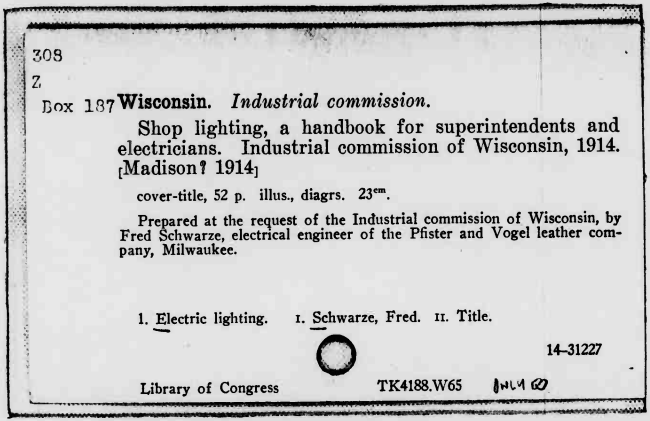

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Prepared at the request of the Industrial commission of Wisconsin, by Fred Schwarze, electrical engineer of the Pfister and Vogel leather company, Milwaukee.

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INTENTIONAL SECOND EXPOSURES DUE TO PHOTOGRAPHS

SHOP LIGHTING

A HANDBOOK FOR
SUPERINTENDENTS AND ELECTRICIANS

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INDUSTRIAL COMMISSION
OF WISCONSIN
1914

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INDUSTRIAL COMMISSION OF WISCONSIN

C. H. CROWNHART, Chairman of the Commission

J. D. BECK
C. W. PRICE, Secretary of the Commission

FRED M. WILCOX
PAUL F. WATRUS, Secretary

Issued March 1, 1914

SHOP LIGHTING

FOREWORD

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Mr. Schwarze was a member of the committee on sanitation which drafted the orders on shop lighting included in bulletin Vol. 2, No. 1, issued under date of January 20, 1913.

The commission is issuing this bulletin because of the widespread demand for reliable information which has been found among the manufacturers. Much of the literature on the subject is written in technical language and seldom finds its way to the manufacturer. The manufacturers demand information which is based on practical experience, and which is formulated in plain shop English. The commission feels that Mr. Schwarze has met this need in a most able manner and has prepared a bulletin which will be generally appreciated by the manufacturers and will help them to work out their problems.

From the reports which the commission is receiving from its deputies in the field it is evident that manufacturers over the state are waking up to the value of good light in shops—not only its economic value, but especially its value in preventing accidents. Those manufacturers who have the best lighted shops are the most positive in their recommendation of the practical value of good natural and artificial light.

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By FRED SCHWARZE.
Electrical Engineer—Pfister & Vogel Leather Company, Milwaukee.

INTRODUCTION.

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Chapter VI will be of special interest to electricians who are responsible for installations. In this chapter we include specific recommendations covering types of lamps, reflectors,

Pfister & Vogel Tannery. Shaving Department. General Illumination. 1/8 rated c. p. per sq. floor ft.

Pfister & Vogal Tannery. Staking Department. General Illumination 1/4 rated c. p. per sq. floor ft.

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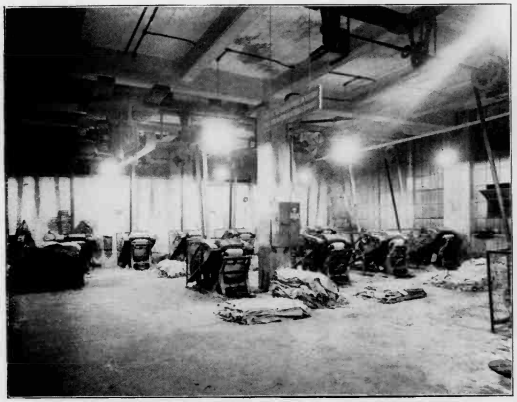
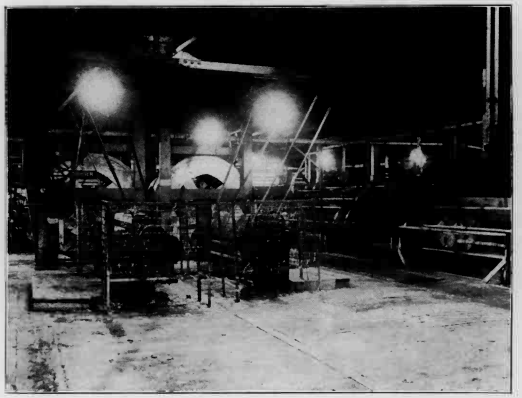


Pfister & Vogel Tannery. Shaving Department. General Illumination. $\frac{1}{28}$ rated c. p. per sq. floor ft.

Pfister & Vogal Tannery. Staking Department. General Illumination $\frac{1}{4}$ rated c. p. per sq. floor ft.

spacing, height, location over machines and benches, and amount of light required. These recommendations cover the following departments and conditions:

Shop rooms with ceilings, 10 to 16 feet
Foundries, forge shops and high buildings
Yards, platforms, etc.
Individual machines
Benches
Drafting rooms
Driveways and passageways between buildings
Departments where there are vapors
Stairways.



Pfister & Vogel Tannery. Beam House. General Illumination. 1/4 rated c. p. per sq. floor ft.

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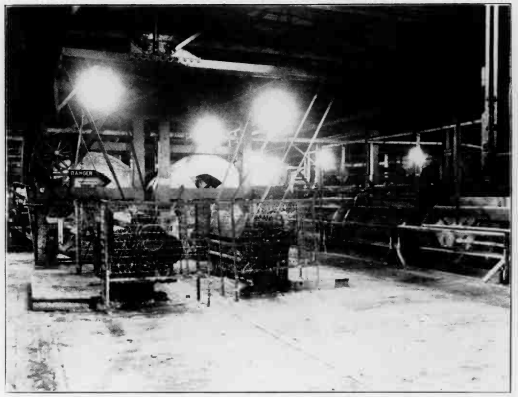
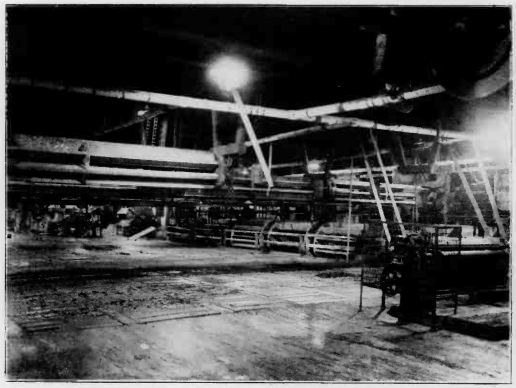


Pfister & Vogel Tannery. Beam House. General Illumination. 1/8 rated c. p. per sq. floor ft.



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CHAPTER I.

GOOD LIGHT SAVES MONEY.

During the past five years manufacturers over the country have begun to wake up to the economic value of good light in shops. For years in this country, we have been manufacturing in the dark. The average installation has consisted of a few little glow-worms of lamps hung above the machines, which furnished practically no general illumination. In many cases these lights were without reflectors and therefore, did not even light the machines properly.

The manufacturers who have done the most in shop lighting are the most enthusiastic in their recommendations of light as a factor of economy. Mr. C. L. Eshleman, in a paper recently published in the proceedings of the American Institute of Electrical Engineers, makes the following statement:—

"Available data shows that an efficient lighting system increases the output from 2 per cent in steel mills to 10 per cent in textile mills and shoe factories. Two hundred and fifty thousand industrial plants in the United States have an annual output of $20,000,000,000. To be ultra-conservative, we will say that there is a saving of only 2 per cent in the annual output. This means a saving of $400,000,000. This enormous sum represents the saving on actual production and leaves us to conjecture what the saving would be if we took into consideration the improved quality of output and the saving due to decrease in accidents. Deducting the first cost of installation and maintenance there is still left an almost incredible amount."

In a certain steel plant, where an efficient lighting system was installed, the output at night was increased a little over 10 per cent. In order to determine whether this was due wholly to the introduction of the better lighting conditions the lamps were taken out and for a time the work was carried on at night with the old lighting system. It was found that the amount of work dropped off over 10 per cent. When,

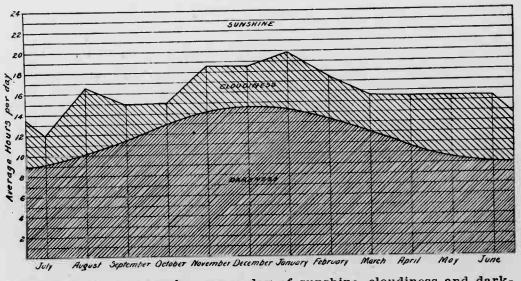

Chart showing average hours per day of sunshine, cloudiness and darkness for each month during 1910, in New York City.

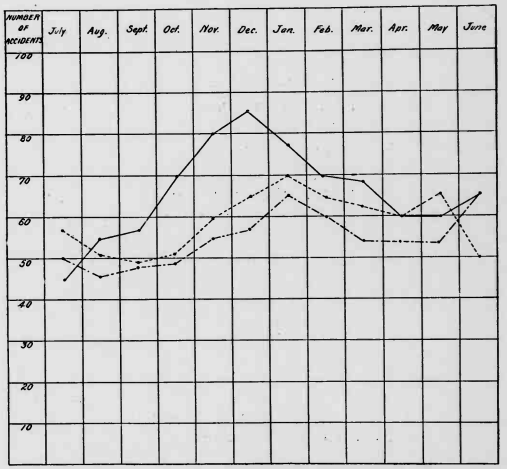

Chart showing the seasonal distribution for three successive years of about 700 deaths annually from industrial accidents reported from an area embracing 80,000 plants.

however, the work was resumed under the improved conditions the men were able again to produce 10 per cent more work.

Manufacturers have been quick to appreciate the economic value of labor saving machinery but have been slow to see that good shop lighting greatly increases the efficiency of both workmen and machines, thereby reducing the amount of defective work.

In view of the fact that a lighting system is in use only about two hours each day, manufacturers have been inclined to look upon the money which is invested in a good lighting system as not yielding good returns.

Good lighting in a factory should be looked upon as a tool—one of the most important tools—because it adds to the efficiency of all the other tools. A factory is a great machine through which a vast stream of materials is moving. These materials are handled by many hands and if these hands are working in the dark it is evident that the movement of the materials must be impeded and consequent loss incurred. We are just beginning to appreciate the effect of eye fatigue on the workman, impairing his health and comfort, and decreasing materially his efficiency. We have hardly begun to think about the psychological effect of good light. There is no doubt that good natural and artificial light make for alertness, cheerfulness and contentment—all of which at last makes for efficiency. It has been estimated that the cost of good artificial lighting for two hours each day is one tenth of one per cent of the workmen's wages. This cost is negligible when compared to the economies.

The value of light for safety is obvious. A number of large concerns which have reduced accidents from 50 per cent to 75 per cent testify that good general illumination is indispensable to safety in shops. It has recently been stated by authorities who have made a study of accidents that 25 per cent of the 500,000 avoidable accidents which occur each year in the United States are caused by bad lighting conditions. On page 7 are given two charts which graphically illustrate the importance of light for safety. The one chart shows the average hours per day of sunshine, cloudiness and darkness in New York City for each month during 1911; the other chart shows the seasonal distribution for three successive years of

W. S. Seaman Co. Automobile Wood Body Frame Department. General Illumination. 1/25 rated c. p. per sq. floor ft.

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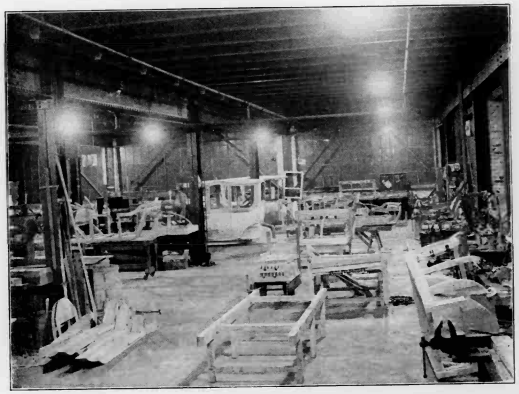


W. S. Seaman Co. Automobile Wood Body Frame Department. General Illumination. 1/2 rated c. p. per sq. floor ft.

W. S. Seaman Co. Automobile Body Finishing Department. General Illumination. 1/2 rated c. p. per sq. floor ft.

about 700 deaths annually from industrial accidents reported from an area embracing 80,000 plants. This latter chart was compiled by Mr. John Calder, one of the best authorities on accidents. These charts tell their own story, and leave little room for doubt that good light is indispensable to safety.

CHAPTER II.

TYPES OF LAMPS.

In selecting the type of lamp for a given installation reliability of service and the cost of maintenance should be the first consideration.

There are two principal types of electric lamps for use in factories for purposes of general illumination; incandescent lamps, flaming and luminous arc lamps. There are a number of makes of each of these types and most of them are efficient.

My own experience has led me to favor for general illumination, the high efficiency incandescent lamp, which is known as the tungsten lamp, because its filament is made of tungsten metal. This is the type of lamp which has been adopted as the standard for all installations in the plants of the Pfister & Vogel Leather company. The tungsten lamps are now being widely recognized for their efficiency and many of the large manufacturers have adopted them as standards in making new installations.

The marvelous development of the incandescent lamp and its wide use and adaptation compared with a few years ago, leads me to believe that it has come to stay and that further improvements will be made with respect to increasing its efficiency and durability.

The adaptability of present type reflectors to types of the incandescent lamp which may be developed and placed on the market later, is an open question, but undoubtedly same can be adapted to a greater extent, and with the development of the lamp will follow changes in the design of reflectors which will meet the specific needs.

The small amount of maintenance effort required to operate a system composed of incandescent units should be a great factor in determining the selection of the same.

I might say in passing that for insallations, in such plants as high-roofed steel works and foundries where there are cranes and where the lamps are hung at a height of over 35 feet, I should recommend the use of the flaming arc

lamp, although clusters of tungsten lamps and large unit tungsten lamps have been installed in such plants and have given satisfactory results.

For all installations at a height less than 40 feet I strongly favor the tungsten lamps. On installations above this height, where the tungsten lamp cannot be used, the flaming arc lamp is recommended. However, the new type of tungsten * lamp which has just been put on the market should fulfill many requirements which heretofore have been filled by the flaming arc lamp. These lamps are at present being made in sizes and with efficiencies, life ratings and prices as follows: †

Rated watts	Approximate watts per candle power	Approximate candle power	Average hours life	List prices
400	.80	500	1000	$5.00
750	.70	1070	1000	8.00
1000	.65	1530	1000	6.50 8.00

Above prices subject to discounts varying from 10 to 35 per cent, depending on the quantities purchased.

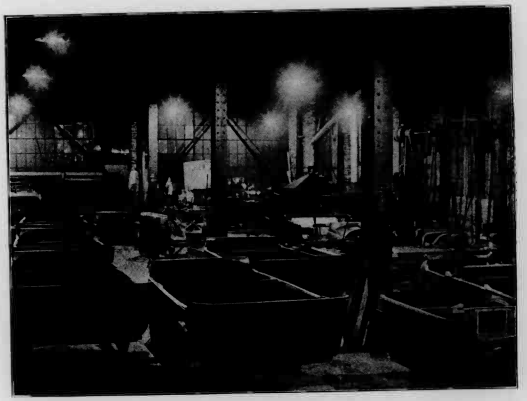
From this data it can readily be seen that with an average efficiency of approximately .7 watts per candle power, and a maximum rating of 1530 candle power the new type of tungsten lamp should adapt itself readily to conditions as outlined in preceding paragraphs. The question of initial cost, maintenance, expense, comparative efficiency and adaptability of the new type of tungsten lamp and the flaming arc lamp can be readily determined by experiments under actual conditions.

Where the building is narrow and the ceiling is high, the tungsten units equipped with angular reflectors can be used when supported by brackets attached to columns or walls. For reflector see Figure 22, page 43.

The ordinary wire drawn tungsten lamp is an economical lamp, consuming from 1 to 1¼ watts per rated mean horizontal candle power, while the old type of carbon filament incandescent lamp, which has been so generally used, consumes from 3 1-10 to 3½ watts per candle power. The Tungsten lamp can be used satisfactorily with 220 volts or less.

The rated life of the tungsten lamp is from 1000 to 1700 hours, but it has been found from experience that the actual life of the 60 watt and larger lamps exceeds the rated

*At present commonly called the nitrogen tungsten unit.
†Prices subject to change.



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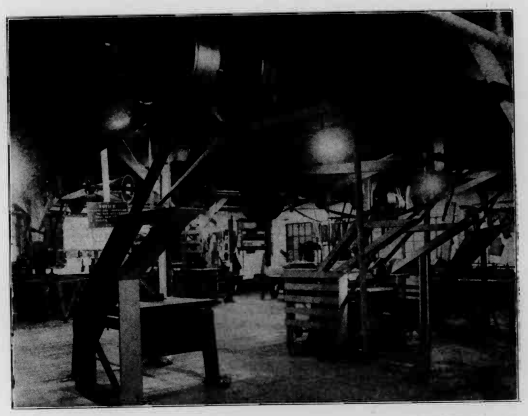

Pfister & Vogel Tannery. Carpenter Shop. General Illumination. ¼ rated c. p. per sq. floor ft.

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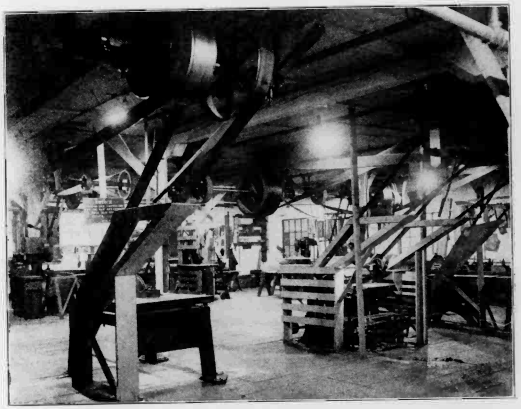
W. S. Seaman Co. Automobile Metal Body Department. General Illumination. 1¼ rated c. p. per sq. floor ft.



Pfister & Vogel Tannery. Carpenter Shop. General Illumination. ¼ rated c. p. per sq. floor ft.

life. The first tungsten lamps, made four or five years ago, were fragile and for this reason many people still think this lamp is not suitable for factories. The new type of tungsten lamp is made with a drawn wire filament and is strong and durable. Our experience has demonstrated that they are suitable for any condition found in factories.

Where there is excessive vibration, which is rarely found, we have found it advisable to loop the suspending cord and

Pfister & Vogel Tannery. Tacking Department. General Illumination.

insert a coiled spring made of number 14 gauge, brass or phosphor bronze wire, as a shock absorber.

The color of the light from the tungsten lamp closely resembles sunlight, and is pleasing and agreeable to the eyes. It gives a bright and cheerful effect to a room, which is most desirable.

An important point regarding the tungsten lamps is the fact that the maximum candle power is in a horizontal direction from the lamp,—being about six and one-half times greater than the light thrown downward. This fact makes it possible to so design reflectors as to perfectly control the light and redirect and focus it on the working plane, or give it wide distribution over a given floor space.

In the selection of lamps it is important that the voltage of same shall correspond as nearly as possible to the voltage of the circuits on which the lamps are to be used. It is also essential to maintain a steady voltage on lines so as to secure the most efficient results and to avoid unnecessary fluctation.

The tungsten lamps are now made in sizes ranging from 10 watts to 1000 watts, thus making them well adapted for securing a good distribution of light for various conditions.

The approximate costs of the various sizes of regular tungsten lamps mentioned in this bulletin, together with data showing their relative efficiencies, life ratings and mean horizontal candle power ratings are as follows: *

Rated watts.	Watts per mean horizontal candle power.	Mean horizontal candle power.	Average hours of life.	Cost.
20	1.25		1000	$.35
25	1.17	21.4	1000	.35
40	1.17	34.2	1000	.35
60	1.12	53.6	1000	.45
100	1.08	92.6	1000	.80
150	1.03	146.	1000	1.20
250	1.00	250.	1000	2.00
400	1.00	400.	1000	3.60
500	1.00	500.	1000	4.00

The above prices are the list prices in effect July 1, 1913, and are subject to discounts varying from 10 to 35 per cent, depending upon the quantities purchased.

The mean horizontal candle power ratings referred to in the above table are the candle power ratings used in this bulletin in defining the amount of light necessary for various purposes.

The approximate cost of the various sizes of tungstens mentioned in this bulletin is as follows:

25	watt	$ .30
40	"	.30
60	"	.40
100	"	.70
150	"	1.00
250	"	1.75
400	"	3.10
500	"	3.60

*Prices subject to change.

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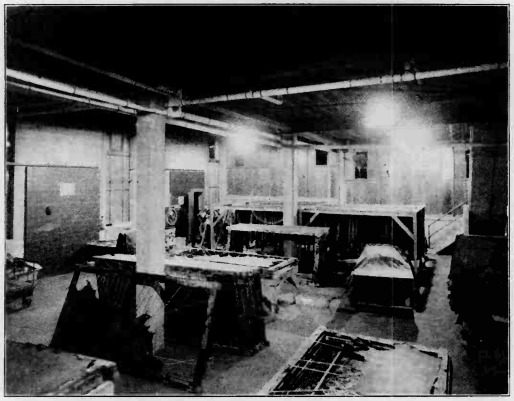


Pfister & Vogel Tannery. Tacking Department. General Illumination.

insert a coiled spring made of number 14 gauge, brass or phosphor bronze wire, as a shock absorber.

The color of the light from the tungsten lamp closely resembles sunlight, and is pleasing and agreeable to the eyes. It gives a bright and cheerful effect to a room, which is most desirable.

An important point regarding the tungsten lamps is the fact that the maximum candle power is in a horizontal direction from the lamp.—being about six and one-half times greater than the light thrown downward. This fact makes it possible to so design reflectors as to perfectly control the light and redirect and focus it on the working plane, or give it wide distribution over a given floor space.

In the selection of lamps it is important that the voltage of same shall correspond as nearly as possible to the voltage of the circuits on which the lamps are to be used. It is also essential to maintain a steady voltage on lines so as to secure the most efficient results and to avoid unnecessary fluctation.

The tungsten lamps are now made in sizes ranging from 10 watts to 1000 watts, thus making them well adapted for securing a good distribution of light for various conditions.

The approximate costs of the various sizes of regular tungsten lamps mentioned in this bulletin, together with data showing their relative efficiencies, life ratings and mean horizontal candle power ratings are as follows: *

Rated watts.	Watts per mean horizontal candle power.	Mean horizontal candle power.	Average hours of life.	Cost.
20	1.25		1000	$.35
25	1.17	21.4	1000	.35
40	1.17	34.2	1000	.35
60	1.12	53.6	1000	.45
100	1.08	92.6	1000	.80
150	1.03	146.	1000	1.20
250	1.00	250.	1000	2.00
400	1.00	400.	1000	3.60
500	1.00	500.	1000	4.00

The above prices are the list prices in effect July 1, 1913, and are subject to discounts varying from 10 to 35 per cent, depending upon the quantities purchased.

The mean horizontal candle power ratings referred to in the above table are the candle power ratings used in this bulletin in defining the amount of light necessary for various purposes.

The approximate cost of the various sizes of tungstens mentioned in this bulletin is as follows:

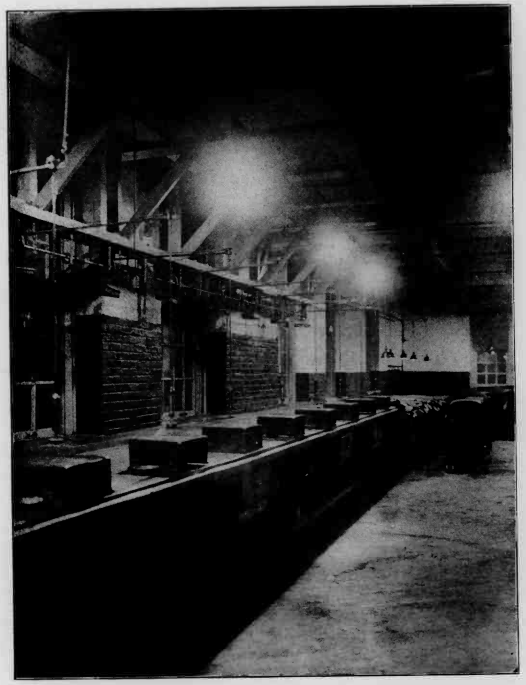
25	watt	$ .30
40	"	.30
60	"	.40
100	"	.70
150	"	1.00
250	"	1.75
400	"	3.10
500	"	3.60

*Prices subject to change.

When possible, it is advisable and more economical, to install single units than clusters. For instance, one 400 watt lamp will emit 12 per cent more light than four 100 watt lamps, and the light which reaches the working plane is increased much more than 12 per cent. It is possible to secure a more even distribution of light by the use of a reflector on a single lamp than on a cluster of lamps. On pages 32 to 38, I have specified the size of lamps which I have found most efficient and economical for various departments and conditions.

On machines and benches where a light is not suspended on a cord but is attached to a bracket, it has been found practical to use tungsten lamps, when ordinary care is exercised and the vibration is not too heavy. The 40 watt tungsten unit has proven more satisfactory because the filament of the smaller sized units is more fragile.

There has been placed on the market what is known as a metallized carbon filament incandescent lamp. This lamp is more efficient than the old type of carbon lamp, using only 2½ watts per candle power, while the old lamps use from 3¼ to 4 watts. We would recommend this lamp for ordinary installations where tungsten lamps cannot be used, either from the standpoint of initial cost or where a jarring or vibration is harmful to such. Under such conditions it has been found necessary to use the ordinary double oval anchored carbon filament lamp. The metalized filament is not as strong as the carbon. It has been demonstrated that the ordinary 16 candle power carbon lamp will give ample light for individual machine service. It is, however, recommended that the tungsten units be adopted wherever feasible, as the increased life of same over the carbon or metallized filament unit is worth considering in addition to the increased efficiency and light of better color value.



Pfister & Vogel Tannery. Finishing Department. General Illumination. ¾ rated c. p. per sq. floor ft.

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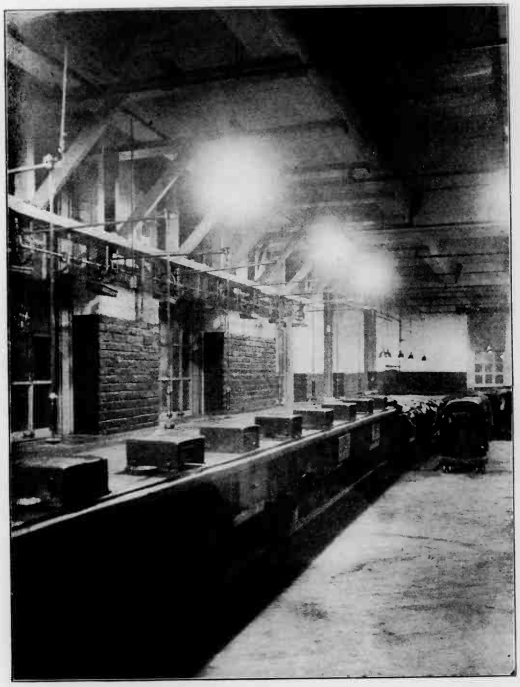

Pfister & Vogel Tannery. Finishing Department. General Illumination. ¾ rated c. p. per sq. floor ft.

CHAPTER III.

REFLECTORS.

In equipping a plant with tungsten lamps one of the indispensable things is to provide properly designed reflectors. The importance of this point was indicated in the last chapter where the statement was made that six and one-half times as much light is thrown horizontally from a tungsten lamp as is thrown downward. I think it is conservative to say that a properly designed reflector will add from 35 to 50 per cent to the efficient use of a tungsten lamp.

There are two principal types of reflectors—the commercial and the industrial. The commercial is usually made of some transparent or translucent material, and is designed to illuminate the ceiling as well as the walls and floors. This type is used extensively in stores, exhibit rooms, etc.

With the industrial type of reflector the one essential requirement is to concentrate the light, and evenly distribute it over the working plane, which is from 3 to 6 feet above the floor, and to allow the minimum amount of light to be wasted on the ceiling.

Reflectors for factories should be made of some strong material which will not corrode, which cannot be effected by the gas and smoke, and which can be easily cleaned. My experience has demonstrated that reflectors made of white porcelain enameled steel fulfill these requirements better than any other. Practically all of the most efficient reflectors now sold on the market for factories are made of porcelain enameled steel. On pages 39 to 43 we show a number of cuts of reflectors and specify the types which we have found to be best suited for various departments and conditions. All of these are made of white porcelain enameled steel. The general design of reflector recommended is of the bowl shaped type. We have found this design to be the most efficient, especially for general illumination. It properly concentrates and distributes the light upon the working plane. A number of manufacturers who have installed tungsten lamps have made the

Pfister & Vogel Tannery. Patent Leather Finishing Department. General Illumination. 4-10 rated c. p. per sq. floor ft.

Pfister & Vogel Tannery. Finishing Department. General Illumination. ¼ rated c. p. per sq. floor ft.

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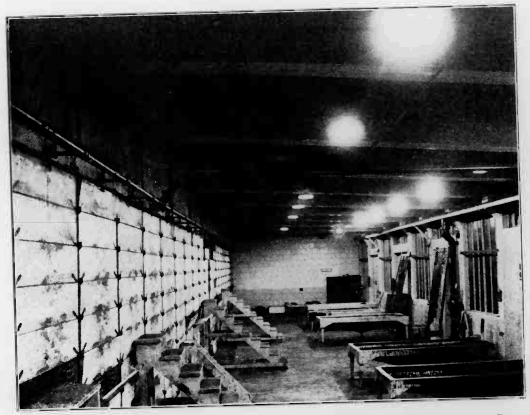

Pfister & Vogel Tannery. Patent Leather Finishing Department. General Illumination. 4-10 rated c. p. per sq. floor ft.

Pfister & Vogel Tannery. Finishing Department. General Illumination. ¼ rated c. p. per sq. floor ft.

mistake of equipping them with flat disk-like reflectors with the result that about 50 per cent of the light is wasted above the plane where the men are working. In the factories of Wisconsin it is probably true that 75 per cent of the departments to be lighted include rooms in which the ceilings are from 10 to 16 feet in height, and where there is no gas or smoke to obstruct the light. To light these rooms properly is the problem in which most manufacturers are particularly interested. On pages 39 to 40 we show 4 cuts of reflectors—Figures 3, 4, 6 and 8. These reflectors are of the bowl type and are about equal in efficiency for installation in rooms as indicated above. The deeper bowl types of reflectors have one advantage over the others; when hung 10 feet from the floor, which is the average height for 100 watt units, the lamp is practically hidden from the eyes of the men who are working in the room, thus avoiding the glare of the light.

For departments such as foundries and forgeshops, where there is gas and smoke and where large unit lamps are hung at a height of 20 feet or more, the types of reflector shown in figures 5 and 7 are recommended.

On pages 41 and 42, Figures 11, 12, 13, 14, 15 and 16, are shown reflectors for machines and benches. These are scientifically designed for efficiency and the different forms and angles make them well adapted to the different positions in which the lights must be placed.

It is exceedingly important in lighting machines and benches that the lamp be so hung or attached that it will be held firmly in position and the light will be hidden from the eyes of the operator.

The bright spot of light from the individual lamp on a machine, when the general illumination of department is not good, often causes eye strain because the eye is continually shifting from the light spot to the dark area. Proper general illumination of the department largely eliminates this strain. A glaring light not only causes eye fatigue but reduces the ability of the eye to perceive any illuminated objects. Alternate increase and decrease of intensity of light as well as flickering of lamps cause eye fatigue and should be avoided.

Many times it is not possible to properly adjust positions of

U. S. Glue Co. Cutting Department. General Illumination. ¼ rated c. p. per sq. floor ft.

U. S. Glue Co. Shipping Department. General Illumination. ¼ rated c. p. per. sq. floor ft.

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lamps, etc., by suspending the lamp on a cord. In such cases a bracket such as as shown in Figures 18 and 19, pages 42 and 43, equipped with reflectors similar to Figures 11, 12, 13, 14 and 15, should be used. Brackets similar to these can be purchased or can be easily made in the shop. These brackets not only hold the lamp firmly, but enable the operator to adjust it for different operations. This use of brackets protects the lamp and reduces largely the cost of breakage.

All reflectors should be kept clean. A clean reflector is 25 per cent to 50 per cent more efficient than one which is covered with dust and smoke. One man should be made responsible for the cleaning of reflectors and lamps used for general illumination. These should be cleaned at least once a month if necessary, and oftener in departments where there is dust, gas or smoke. Workmen should be required to keep the reflectors clean on their machines and benches. The inspector should also see that all sockets are equipped with lamps and the lamps are in good condition.

Pfister & Vogel Tannery. Buffing Department. Individual Lights Required. ¼ rated c. p. per sq. floor ft.

U. S. Glue Co. Warehouse. General Illumination.

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Pfister & Vogel Tannery. Buffing Department. Individual Lights Required. ¼ rated c. p. per sq. floor ft.

U. S. Glue Co. Warehouse. General Illumination.

CHAPTER IV.

AMOUNT OF LIGHT FOR VARIOUS DEPARTMENTS AND CONDITIONS.

The orders of the Industrial commission issued under date of January 20, 1913, reprinted on pages 46 and 48, specify that "places of employment, in which hand or machine operations are performed, must be supplied during working hours, when daylight is not available, with artificial light equivalent in amount, for each 4 square feet of floor space, to not less than the light produced by a one candle power lamp hung 10 feet from the floor."

I was a member of the committee which drafted these orders on light and in working out this standard we considered the experience of a number of large companies, including the International Harvester corporation, and the Pfister & Vogel Leather company, which have adopted this as a minimum standard. During the last three years these companies have made extensive installations after this standard and have found it economical and satisfactory in all departments where close work is not done, but where the rougher hand and machine operations are performed, such as are found in the majority of metal and wood working plants in Wisconsin. This standard is as low a minimum as can be safely adopted to secure results both from the standpoint of safety as well as efficiency. A number of companies have adopted a higher standard. In factories where this standard has been adopted it has been found unnecessary to use individual lights except on machines or benches where fine work is being done; this means a convenience as well as an economy.

In departments in which work on fine machines or hand work is being done, no arbitrary rule can be laid down. The amount of light must be adapted to the work so as to avoid eye strain, and to enable the men to work with accuracy. Two methods have been adopted for lighting such departments—general illumination—and both general and individual lighting. Where general illumination alone is used a standard of one half to one

U. S. Glue Co. Vat House. General Illumination. ⅛ rated c. p. per sq. floor ft.

U. S. Glue Co. Cook House. General Illumination. Vapor proof installation.

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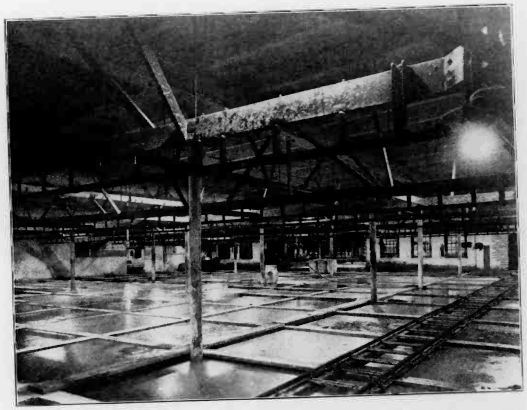
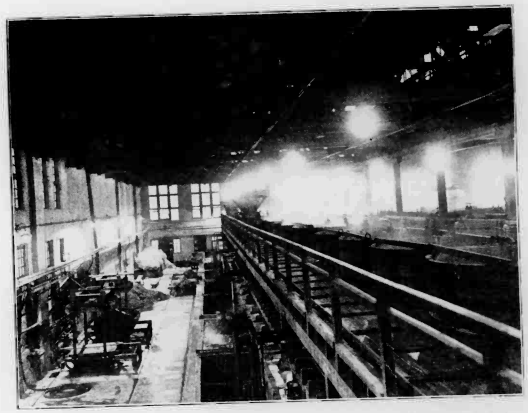


U. S. Glue Co. Vat House. General Illumination. ⅛ rated c. p. per sq. floor ft.



U. S. Glue Co. Cook House. General Illumination. Vapor proof installation.

candle power per square floor foot is often used. Where both general and individual lighting is used, the standard of one-quarter candle power may be safely adopted for the general illumination, and the light for individual machines and benches can be adapted to the needs.

The orders of the Industrial commission require in foundries and forge shops light equivalent to one-quarter candle power per square floor foot. In order to supply this it is necessary to furnish about one-half candle power per square

J. I. Case Threshing Machine Co. Machine Shop. General illumination. Individual machine lights required. ¼ rated c. p. per sq. floor ft.

floor foot, on account of the obstruction of the smoke and gas. This has been found to be a practical standard for foundries.

In warehouses, vat houses and storage places, a standard of one-eighth candle power per square floor foot has been found adequate.

The problem of equipping machines, benches and tables where close, exact work is being done with proper light is most important, and is one which has been grossly neglected in the past. In many factories can be found men working on lathes and punchpresses, with a little glow worm of a lamp hanging beside the machine. Many times the globe of the lamp is dirty and there is no reflector. The light is not properly adjusted to reach the tool, but rather glares in the eyes of the operator and blinds him. This is bad economy and results in inefficient work, and often in injury to the operator's eyes.

The size of lamp best adapted for individual machine and bench lighting is the 16 candle power carbon lamp and the 40 watt tungsten unit. Smaller units are sometimes used with good results, but generally speaking the 16 candle power carbon lamp will give ample light and is the proper standard.

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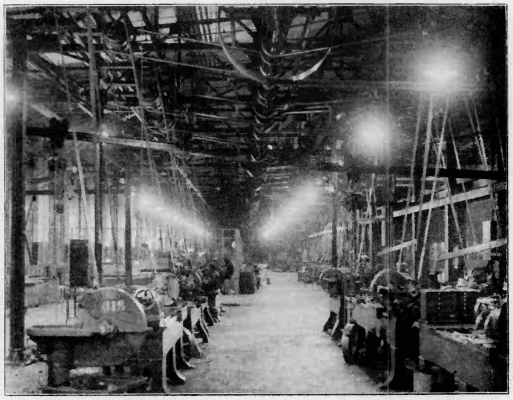

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CHAPTER V.

SUGGESTIONS FOR INSTALLATION.

In installing lighting systems the standards regarding fire protection of the National Board of Underwriters should be strictly adhered to. These standards allow for two types of installation—the metal conduit and the open insulated type with knobs and tubes. The metal conduit installation costs about 50 per cent more than the insulated open knob and tube type of installation. The Board of Underwriters does not allow the open type wiring to be used in basements, on brick or stone walls, or under conditions where deterioration is rapid.

In the Pfister & Vogel Leather company plants we are using the metal conduit for all new installations and believe it is the best for the following four reasons:

1. It is more durable.
2. It is fire-proof.
3. The conductors are protected against abrasions and deterioration.
4. It cannot be easily tampered with.

If insulated cord is used for pendants to suspend reflectors I should recommend No. 18 Packinghouse cord of not less than 15 strands for all lamps of 150 watts or less; for lamps above 150 watts, No. 16 or 14 Packinghouse cord should be used, depending on the size of lamp and length of cord.

All fuses should be of the enclosed type, and these together with switches and other exposed current carrying parts should be encased in metal fireproof boxes. This is now common practice with many manufacturers. In installing lighting systems in departments such as warehouses, vathouses and other departments where it is often desirable to use at one time the lights along one aisle, or in one section of the room, we have found it is economical to install circuit snap switches at convenient points. In Figure 1 on page 38, is shown a good type of snap switch which is made for 1, 2 and 3 group control. A diagram, Figure 2, is also given showing the installation of a two group connection. The two group switch has

proven to be the most practical in most installations. This switch makes it possible to control two groups either separately or collectively.

This switch installed costs about 60 per cent of the cost of two single group switches.

In estimating the cost of installing tungsten lamps for general illumination I have found from experience that the following schedule enables me to make a fairly accurate estimate.

The wire and conduit cost 150 per cent more than the cost of the lamp and the wire and knobs 125 per cent of the cost of the lamp. The labor for conduit installation is approximately 45 per cent of cost of lamp and wiring materials. The labor for open type installations costs approximately 50 per cent of cost of lamp and wiring materials. This does not include the cost of mains and distributing centers.

Add to this the cost of reflector to get the total cost. I give below two typical cases.

Conduit Installation.

Tungsten lamp	$ .70
Conduit and wire, etc.	1.75
Labor	1.12
Reflectors	1.25
Total	$4.82

Open type installations.

Tungsten lamp	$ .70
Wiring materials	.70
Labor	.70
Reflector	1.25
Total	$3.35

In departments where there is excessive vapor or gas a vapor proof fixture, similar to the one shown in Figure 20, page 43 may be used. This type of fixture protects the lamp and socket from corrosion and allows for convenient cleaning of globe.

It has been found that the regular porcelain enameled steel reflector can be used in departments where gases, fumes and

moisture exist providing all defects in porcelain are covered with acid proof paint or compound. It is further necessary to protect the brass base of lamp and the socket. This may be accomplished by inserting a flat soft rubber gasket over the lower end of the lamp bulb. This gasket should fit snugly into the neck of the reflector when the lamp is screwed into the socket.

Pfister & Vogel Tannery. Splitting Knife Grinder. General Illumination with adjustable individual light attached to fixture.

CHAPTER VI.

STANDARDS RECOMMENDED FOR VARIOUS DEPARTMENTS AND CONDITIONS.

In planning an installation for a department a careful study should first be made of all conditions. First the location of individual lights for illuminating particular machines or working planes should be determined. Wherever possible this should be accomplished by the use of overhead units which will contribute to the general illumination because the ordinary drop light does not add materially to the same. These lights should be so located as to avoid shadows. The general illumination from the lights over individual machines should be considered in laying out the installation of additional units for the general lighting of the department. It is important to so arrange these light units that the intensity of illumination will be greatest at the points where actual work is being done. In accomplishing this care should be taken to avoid shadows made by workmen's bodies, tools and other objects. In buildings where there are columns or posts the light units should be so arranged as to practically eliminate shadows from same. In carrying out this plan it will be found that the units cannot always be arranged regularly over the room but must be so located as to distribute the light to the best advantage to all parts of the room. Individual drop lights should be avoided as far as possible. The general lighting units should be so arranged as to give local illumination. This will largely eliminate drop lights.

When the spacing between overhead units used for individual lighting is such that an intermediate unit may be required to give sufficient general illumination it has been found to be good practice to increase the size of such units rather than to install the additional units. This can be done if the ceiling is of sufficient height and the spacing between lamps is not too great.

I have thought it would be useful to the manufacturers and their electricians to include in this chapter specific recommen-

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STANDARDS RECOMMENDED FOR VARIOUS DEPARTMENTS AND CONDITIONS.

In planning an installation for a department a careful study should first be made of all conditions. First the location of individual lights for illuminating particular machines or working planes should be determined. Wherever possible this should be accomplished by the use of overhead units which will contribute to the general illumination because the ordinary drop light does not add materially to the same. These lights should be so located as to avoid shadows. The general illumination from the lights over individual machines should be considered in laying out the installation of additional units for the general lighting of the department. It is important to so arrange these light units that the intensity of illumination will be greatest at the points where actual work is being done. In accomplishing this care should be taken to avoid shadows made by workmen's bodies, tools and other objects. In buildings where there are columns or posts the light units should be so arranged as to practically eliminate shadows from same. In carrying out this plan it will be found that the units cannot always be arranged regularly over the room but must be so located as to distribute the light to the best advantage to all parts of the room. Individual drop lights should be avoided as far as possible. The general lighting units should be so arranged as to give local illumination. This will largely eliminate drop lights.

When the spacing between overhead units used for individual lighting is such that an intermediate unit may be required to give sufficient general illumination it has been found to be good practice to increase the size of such units rather than to install the additional units. This can be done if the ceiling is of sufficient height and the spacing between lamps is not too great.

I have thought it would be useful to the manufacturers and their electricians to include in this chapter specific recommen-

dations for lighting installations covering the more important departments and conditions found in the factories of Wisconsin.

In offering these recommendations, as stated before, I am not pretending to give the final word on shop lighting, but merely placing before the manufacturers the results of my own experience.

I give these recommendations under nine headings, and under each heading is included a brief list of details.

1. DEPARTMENTS WITH CEILINGS 11 TO 16 FEET IN HEIGHT, WHERE THERE IS NO GAS OR SMOKE.

(a) **Type of Lamp.** Tungsten—100 watts.

(b) **Type of Reflector.** Similar to design shown in figures 3, 4, 6, 7 and 8, pages 39 and 40.

(c) **Height.** 10 feet to bottom of reflector.

(d) **Spacing.** Need not be arranged regularly over room, but should be so placed as to give the best results for individual machines and benches; but should be approximately 18 foot centers. Care should be taken to arrange the lamps so as to avoid shadows from piles, machines, beams, pillars, etc. and also the tools and workmen's bodies.

(e) **Minimum Amount of Light.** One-fourth of a candle power per square floor foot as a minimum for safety and efficiency in departments where coarse work is done, such as the ordinary wood and metal working shops. In departments where finer work is done, one-half to one candle power per square floor foot is necessary to give good results.

2. DEPARTMENTS WITH CEILINGS 9 to 11 FEET IN HEIGHT, WHERE THERE IS NO GAS OR SMOKE.

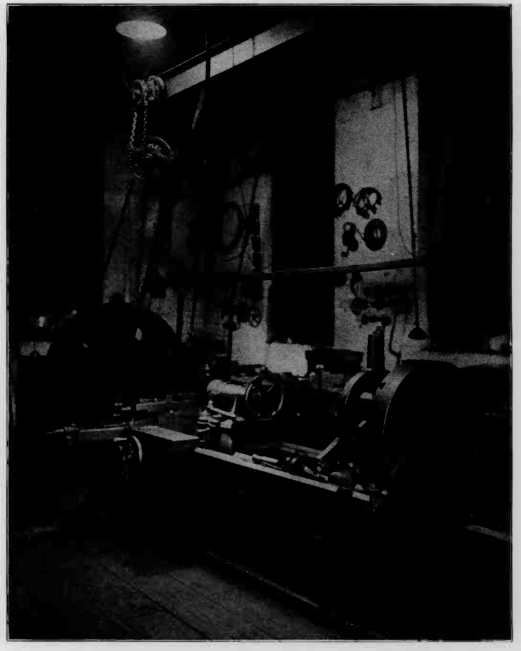
(a) **Type of Lamp.** Tungsten—60 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 17, page 42.

(c) **Height.** 8 to 10 feet (as high as possible).

(d) **Spacing.** 12 to 14 foot centers. Need not be arranged regularly over the room, but should be so placed as to give the best results for individual machines and benches.

(e) **Minimum Amount of Light.** One-fourth candle power



Pfister & Vogel Leather Co. Individual Lighting of Lathe.

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In offering these recommendations, as stated before, I am not pretending to give the final word on shop lighting, but merely placing before the manufacturers the results of my own experience.

I give these recommendations under nine headings, and under each heading is included a brief list of details.

1. DEPARTMENTS WITH CEILINGS 11 TO 16 FEET IN HEIGHT, WHERE THERE IS NO GAS OR SMOKE.

(a) **Type of Lamp.** Tungsten—100 watts.

(b) **Type of Reflector.** Similar to design shown in figures 3, 4, 6, 7 and 8, pages 39 and 40.

(c) **Height.** 10 feet to bottom of reflector.

(d) **Spacing.** Need not be arranged regularly over room, but should be so placed as to give the best results for individual machines and benches; but should be approximately 18 foot centers. Care should be taken to arrange the lamps so as to avoid shadows from piles, machines, beams, pillars, etc. and also the tools and workmen's bodies.

(e) **Minimum Amount of Light.** One-fourth of a candle power per square floor foot as a minimum for safety and efficiency in departments where coarse work is done, such as the ordinary wood and metal working shops. In departments where finer work is done, one-half to one candle power per square floor foot is necessary to give good results.

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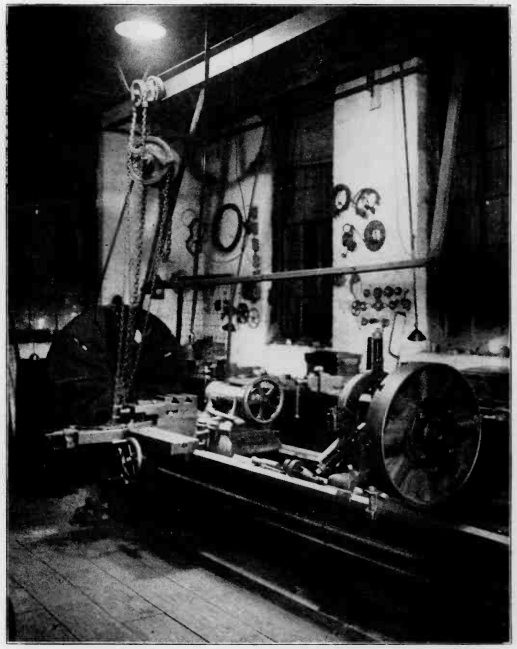


Pfister & Vogel Leather Co. Individual Lighting of Lathe.

per square floor foot in departments where coarse work is done; one-half to one candle power per square floor foot where fine work is being done.

3. FOUNDRIES AND FORGE SHOPS.

(a) **Type of Lamp.** Tungsten—250 watts, when hung at height of 20 feet or less; 400 to 500 watts when hung over 20 feet. Flaming arc lamps for all installations over 40 feet in height, where tungsten lamps cannot be installed. The new type of tungsten lamp can be used in most cases where flaming arc lamps are used. See Chapter 2 for further data.

Note. Where the foundry is narrow and the ceiling is high the tungsten units, equipped with angular reflectors, can be used when supported by brackets attached to columns or walls. For reflectors see Figure 22, page 43.

(b) **Type of Reflector.** Similar to designs shown in Figures 5 and 7, pages 39 and 40.

(c) **Height.** 20 feet where no cranes or other obstructions interfere.

(d) **Spacing.** Should be arranged uniformly over room.

(e) **Minimum Amount of Light.** One-half candle power per square floor foot.

4. STAIRWAYS.

(a) **Type of Lamp.** Tungsten—40 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 9, page 40.

(c) **Height.** As high as ceiling will permit.

(d) **Location.** Where there is one flight of stairs from one floor to the other, one light on each floor is required. Where there are two flights of stairs between floors, running in opposite directions, a light should be placed over center of floor landings only.

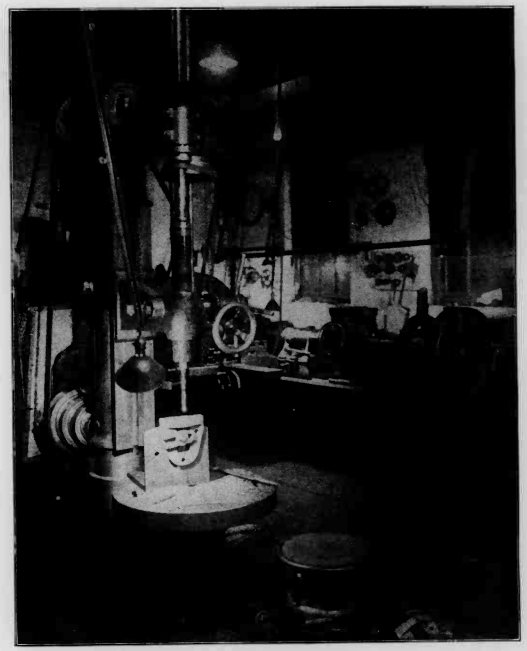
(e) **Minimum Amount of Light.** One 40 watt lamp for each stairway.

5. PLATFORMS.

(a) **Type of Lamp.** Tungsten—60 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 21, page 43.

(c) **Height.** 12 feet if possible.



Pfister & Vogel Leather Co. Individual Lighting of Drill Press.

per square floor foot in departments where coarse work is done; one-half to one candle power per square floor foot where fine work is being done.

3. FOUNDRIES AND FORGE SHOPS.

(a) **Type of Lamp.** Tungsten—250 watts, when hung at height of 20 feet or less; 400 to 500 watts when hung over 20 feet. Flaming arc lamps for all installations over 40 feet in height, where tungsten lamps cannot be installed. The new type of tungsten lamp can be used in most cases where flaming arc lamps are used. See Chapter 2 for further data.

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(b) **Type of Reflector.** Similar to designs shown in Figures 5 and 7, pages 39 and 40.

(c) **Height.** 20 feet where no cranes or other obstructions interfere.

(d) **Spacing.** Should be arranged uniformly over room.

(e) **Minimum Amount of Light.** One-half candle power per square floor foot.

4. STAIRWAYS.

(a) **Type of Lamp.** Tungsten—40 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 9, page 40.

(c) **Height.** As high as ceiling will permit.

(d) **Location.** Where there is one flight of stairs from one floor to the other, one light on each floor is required. Where there are two flights of stairs between floors, running in opposite directions, a light should be placed over center of floor landings only.

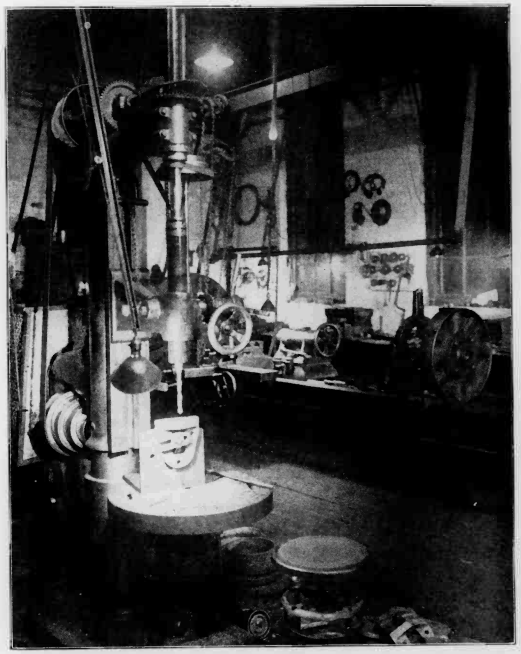
(e) **Minimum Amount of Light.** One 40 watt lamp for each stairway.

5. PLATFORMS.

(a) **Type of Lamp.** Tungsten—60 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 21, page 43.

(c) **Height.** 12 feet if possible.



Pfister & Vogel Leather Co. Individual Lighting of Drill Press.

(d) **Spacing.** Over center of platform if platform is covered; if not, lamps should be attached to pipe fixtures about 4 feet long. When platform is more than 12 feet wide and not covered, reflectors on these fixtures should be placed at an angle of 30 degrees with horizontal line.

(e) **Minimum Amount of Light.** One-eighth candle power per square floor foot.

6. DRIVEWAYS AND PASSAGEWAYS BETWEEN BUILDINGS.

(a) **Type of Lamp.** Tungsten—150 watt.

(b) **Type of Reflector.** Similar to design shown in Figure 21, page 43.

(c) **Height.** 16 feet.

(d) **Location.** Pipe fixtures 4 feet 6 inches from building.

(e) **Minimum Amount of Light.** One-twelfth candle power.

7. YARDS.

(a) **Type of Lamp. Tungsten**—400 watt.

(b) **Type of Reflector.** Similar in design to one shown in Figure 21, page 43.

(c) **Height.** 20 feet.

(d) **Spacing.** 175 foot centers; when buildings obstruct, lights arranged accordingly. Lights should be placed so as to give light to roadways.

8. INDIVIDUAL MACHINES.

(a) **Type of Lamp.** 40 watt metallized carbon filament lamp or 16 candle power carbon filament lamp where attached to machine with brackets; 40 watt tungsten lamp or 16 candle power carbon filament lamp where hung on cords.

(b) **Type of Reflector.** Similar to design shown in Figures 11, 12, 13, 14, 15, 16, 18 and 19, on pages 41 to 43.

(c) **Location.** Attached or hung so that maximum light reaches tool, and light is hidden from eyes of operator, and shadows are avoided. On such machines as punch presses and drill presses, where operator sits close to the machine and feeds, the light should be hung over the center of the space between the operator and the machine. If more than two operators are working together, side by side, the light for general illumination should be hung between them. Where it is desirable to use the general illumination for lighting large machines such as wood planers, the light should be hung over the center of the machine.

Amount of Light. Sufficient to prevent eye strain and enable operator to do efficient work.

Pfister & Vogel Tannery. Glazing Jacks. Individual Lighting.

9. BENCHES.

(a) **Type of Lamp.** Tungsten 40 watt, 20 watt metallized filament, or 16 candle power carbon lamp.

Note. Where possible, use general illumination rather than individual bench lighting.

(b) **Type of Reflector.** Similar to design shown in Figure 16, page 42.

(c) **Height.** Bottom of reflector about 4 feet from floor. The cord should be provided with an adjuster.

(d) **Location.** 18 inches from edge of table.

(e) **Amount of Light.** Sufficient to prevent eye strain and enable operator to do efficient work.

(d) **Spacing.** Over center of platform if platform is covered; if not, lamps should be attached to pipe fixtures about 4 feet long. When platform is more than 12 feet wide and not covered, reflectors on these fixtures should be placed at an angle of 30 degrees with horizontal line.

(e) **Minimum Amount of Light.** One-eighth candle power per square floor foot.

6. DRIVEWAYS AND PASSAGEWAYS BETWEEN BUILDINGS.

(a) **Type of Lamp.** Tungsten—150 watt.

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(d) **Location.** Pipe fixtures 4 feet 6 inches from building.

(e) **Minimum Amount of Light.** One-twelfth candle power.

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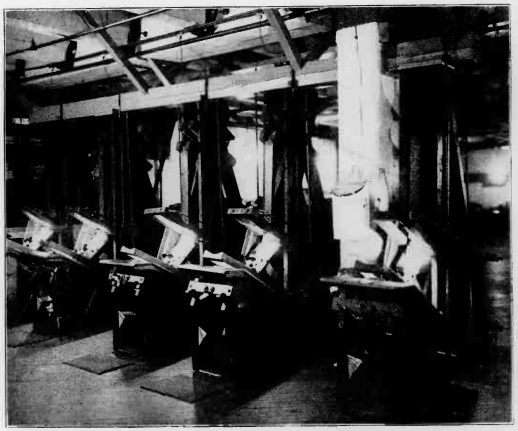
Amount of Light. Sufficient to prevent eye strain and enable operator to do efficient work.



Pfister & Vogel Tannery. Glazing Jacks. Individual Lighting.

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Note. Where possible, use general illumination rather than individual bench lighting.

(b) **Type of Reflector.** Similar to design shown in Figure 16, page 42.

(c) **Height.** Bottom of reflector about 4 feet from floor. The cord should be provided with an adjuster.

(d) **Location.** 18 inches from edge of table.

(e) **Amount of Light.** Sufficient to prevent eye strain and enable operator to do efficient work.

10. DRAFTING TABLES.

(a) **Type of Lamp.** 40 watt tungsten (use two lamps).

(b) **Type of Reflector.** Similar to design shown in Figures 16 and 17, page 42.

Reflectors, Figures 11 and 16 can be used on fixture, Figure 18.

(c) **Height.** 42 inches above table.

(d) **Location.** Central so each unit illuminates one-half of table and is adjustable.

(e) **Amount of Light.** Two 40 watt lamps for each draftsman.

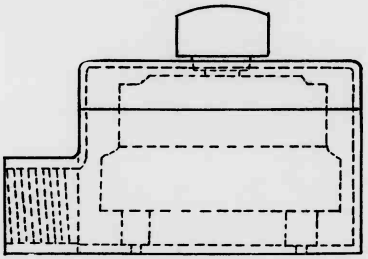

FIGURE 1.

Conduit enclosing fitting and switch.

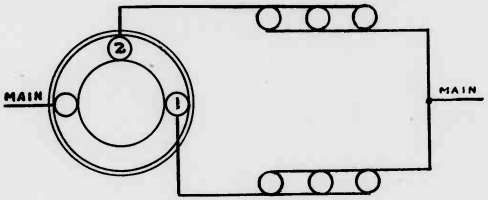

FIGURE 2.

Diagrammatic grouping of two circuit switch.

GROUPS ONE AND TWO CONTROLLED EITHER SEPARATELY OR COLLECTIVELY.

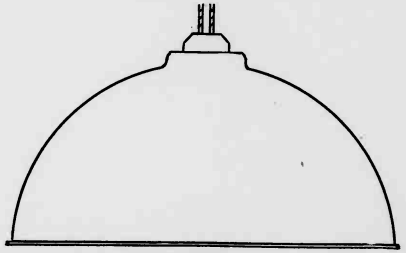

FIGURE 3.

16" reflector.

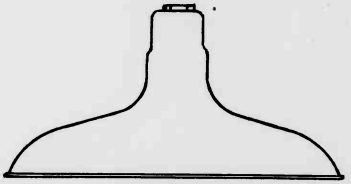

FIGURE 4.

14" reflector.

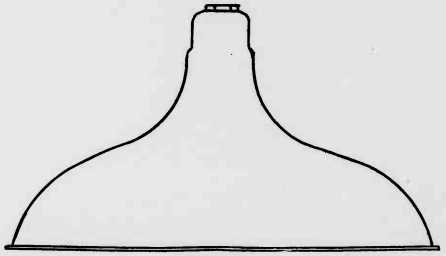

FIGURE 5.

18" reflector.

ALL REFLECTORS RECOMMENDED IN THIS BULLETIN ARE MADE OF PORCELAIN ENAMELED STEEL

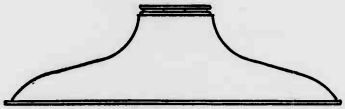

FIGURE 6.
14" reflector.

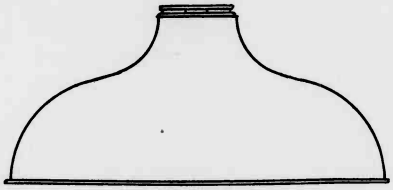

FIGURE 7.
16" reflector.

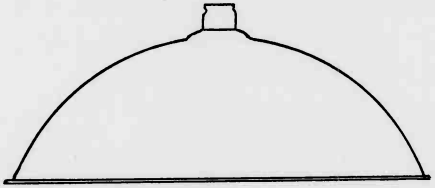

FIGURE 8.
18" reflector.

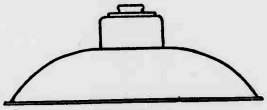

FIGURE 9.
10" reflector.

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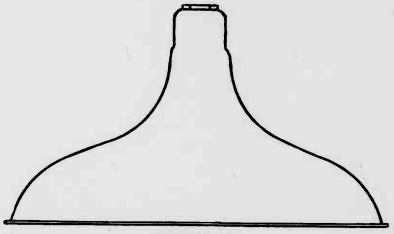

FIGURE 10.
16" reflector.

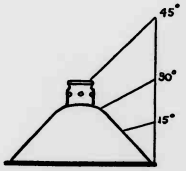

FIGURE 11.
6½" reflector.

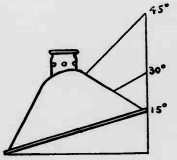

FIGURE 13.
6½" reflector.

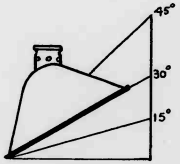

FIGURE 12.
6½" reflector.

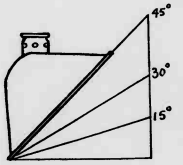

FIGURE 14.
6½" reflector.

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FIGURE 15.
Half reflector.

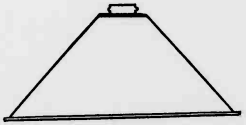

FIGURE 16.
10" reflector.

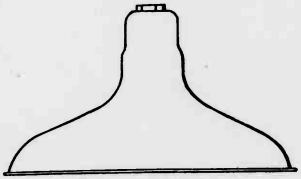

FIGURE 17.
12" reflector.

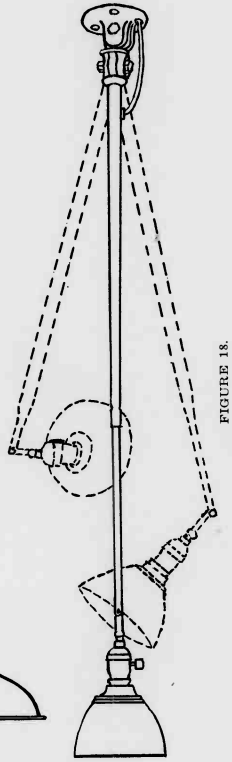

FIGURE 18.
Adjustable telescope fixture.

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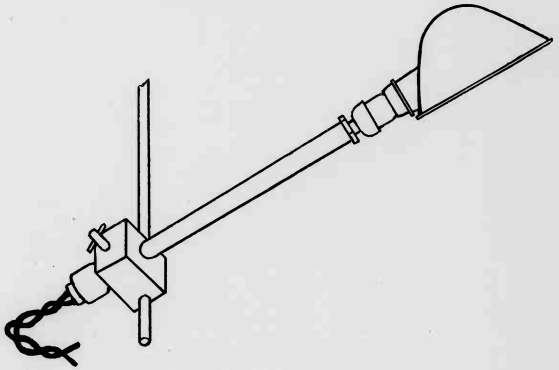


FIGURE 19.
Adjustable machine tool lamp fixture.

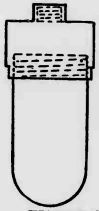
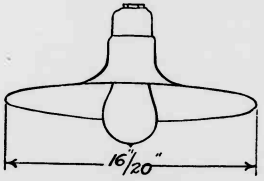
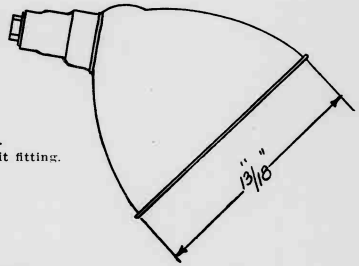


FIGURE 20.
Vapor proof conduit fitting.



Reflector Figure 21.



Reflector Figure 22.

ALL REFLECTORS RECOMMENDED IN THIS BULLETIN ARE MADE OF PORCELAIN ENAMELED STEEL

CHAPTER VII.

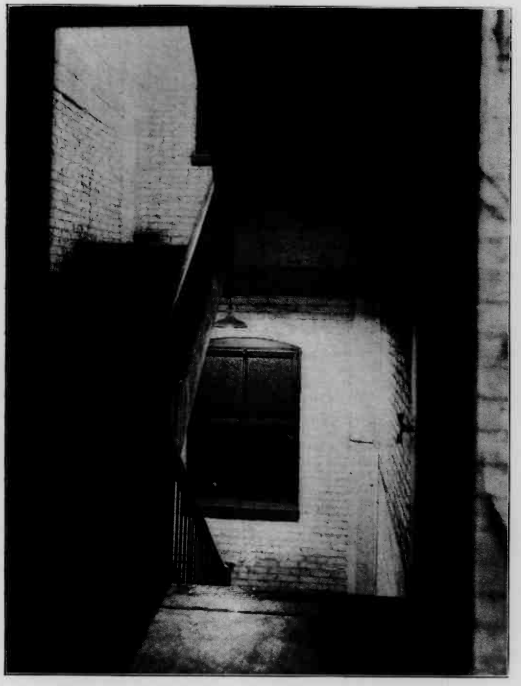
NATURAL LIGHT.

I do not think it is necessary in this bulletin to go into the subject of the construction of new shop buildings to secure adequate natural light. The fact that practically all new factory buildings now being erected are well equipped with windows is evidence of the fact that manufacturers generally are alive to the importance of this subject.

Many of the one story factory buildings are constructed with saw tooth roofs, which have been found to give very satisfactory results. In old factories which are dark, much can be done to increase the light. The walls and ceilings should be kept well whitened with whitewash or water paint. This will increase the distribution of the natural and artificial light approximately 20 per cent. It also adds materially to the natural light to keep the windows clean.

In wide rooms where the ceilings are low and the window space is limited it has been found effective to install prism glass in the windows. This admits a larger amount of light and diffuses it over the room.

In concluding this bulletin I wish to say that any manufacturer who will make a careful study of the conditions in his own plant will soon discover the economic value of efficient light, both natural and artificial. While much definite information has been included in this bulletin in regard to installations, yet it devolves upon each manufacturer to study his own conditions and to adapt his lighting systems to the needs of his work.



Pfister & Vogel Tannery. Stairway. 40 Watt Lamp.

CHAPTER VII.

NATURAL LIGHT.

I do not think it is necessary in this bulletin to go into the subject of the construction of new shop buildings to secure adequate natural light. The fact that practically all new factory buildings now being erected are well equipped with windows is evidence of the fact that manufacturers generally are alive to the importance of this subject.

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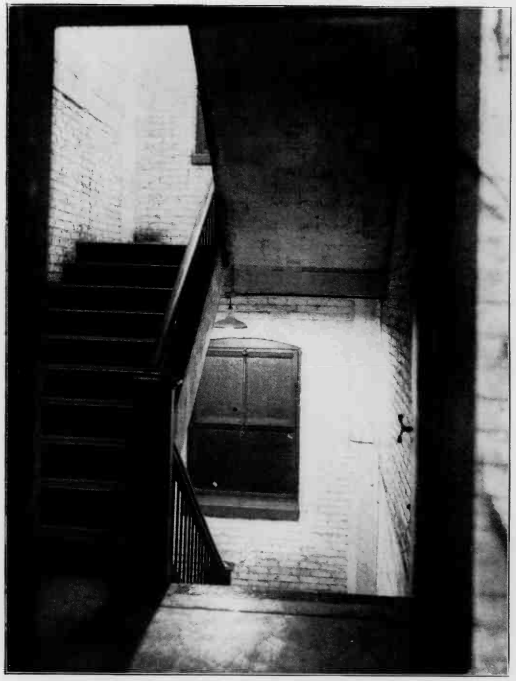

Pfister & Vogel Tannery. Stairway. 40 Watt Lamp.

CHAPTER VIII.

ORDERS OF INDUSTRIAL COMMISSION ON SHOP LIGHTING.

Issued Jan. 20, 1913.

SHOP LIGHTING.

Order 2100—Natural Light Required. Each place of employment *hereafter constructed* must be supplied with adequate natural light during the working daylight hours.

Order 2101—Artificial Light Required. Each place of employment *at present constructed* and which is not so equipped as to furnish adequate natural light during the working daylight hours, must be supplied with artificial light as specified in Orders 2102 to 2105, inclusive.

Order 2102—Artificial Light Where no Gas or Smoke. Each place of employment in which hand or machine operations are performed, must be supplied during the working hours, when daylight is not available, with artificial light equivalent in amount, for each 4 square feet of floor space, to not less than the light produced by a one candle power lamp hung 10 feet from the floor.

Order 2103—Artificial Light Where Gas and Smoke. In foundries, forge shops and other industries where there is smoke and gas which obstruct the light, sufficient artificial light must be supplied to overcome the obstruction and to furnish the standard amount of light on the floor specified in Order 2102.

NOTE. It has been found from experience in foundries and forge shops, that the proper amount of light is secured when the standard of light specified in Order 2102 is increased 100 per cent.

Order 2104—Warehouses and Storage Places. Each place of employment in which hand or machine operations are not performed, such as warehouses, vat rooms and storage places, must be supplied during the working hours, when daylight is

Pfister & Vogel Leather Co. Yard Lighting Between Buildings.

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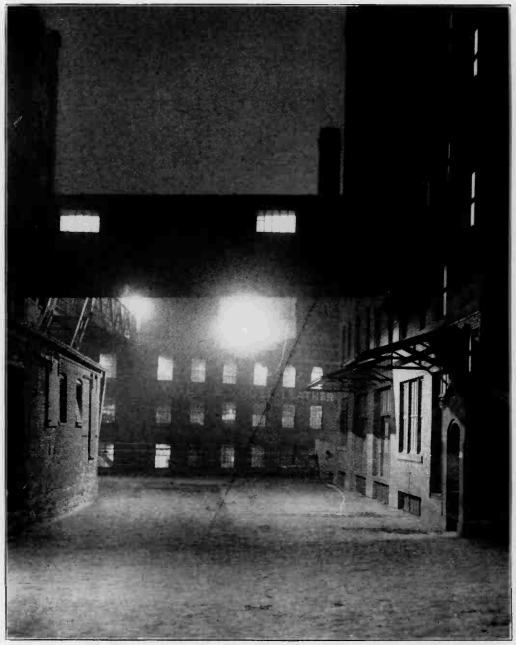
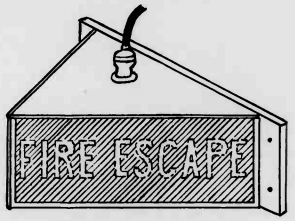


Pfister & Vogel Leather Co. Yard Lighting Between Buildings.

not available, with artificial light equivalent in amount for each 8 square feet of floor space, to not less than the light produced by a one candle power lamp hung 10 feet from the floor.

Order 2105—Light for Fine Work. In each place of employment where fine or close work is being done, such as fine lathe work, engraving, typesetting and drafting, and where the standard of light specified in Orders 2102 and 2103 is not



FIRE ESCAPE EXIT LANTERN

Pfister & Vogel Leather Co.

sufficient to prevent injurious eye strain, sufficient light must be provided in every case to avoid unnecessary eye strain.

NOTE. In many cases it is advisable to provide individual lights for each machine, bench or table. It is exceedingly important that these lights be equipped with proper reflectors which can be kept clean, and which so reflect the light that the eyes are not subjected to the glare of the light, and eye strain is avoided

Order 2106—Yards, Roadways, etc. All yards, roadways, stairways, tramways, and other places outside of buildings which are frequented by employes in the course of their employment, must be supplied with natural or artificial light during the working hours so that every part of such place is easily discernible.

NOTE. (a) Standards Based on Experience—The standards for artificial lighting specified in Orders 2100 to 2106, inclusive, are based on the experience of a large number of reputable manufacturing concerns which have worked out the problems of shop lighting, both from the standpoint of *efficiency* as well as *safety*. These standards are as low as can be safely adopted

to secure results. Many concerns have adopted standards considerably higher than these. The standards of light for departments in which hand or machine operations are performed, as specified in Orders 2102 and 2103, have been found to be adequate for a large per cent of the factories in which wood-working machinery is operated, and in factories in which coarse work is being done on benches, forges or on metal working machines. In such factories where the proper standard of general illumination has been installed, it has been found unnecessary to use individual lights.

NOTE. (b) Reflectors for Lamps—Each lamp used for either general illumination or individual lighting should be equipped with a reflector made of white enameled steel, porcelain, glass or similar material which will not be tarnished by the gas and smoke, and which can be kept clean. The reflectors used for general illumination should be so shaped as to concentrate and distribute the light on the working plane which is usually within seven feet of the floor. It has been found that a properly designed reflector will add about 35 per cent to the efficiency of the lamp. These reflectors should be kept clean. It has been demonstrated that it adds from 25 per cent to 50 per cent to the efficiency of a reflector, to keep it clean.

NOTE. (c) Walls Whitened—Windows Clean—In all places of employment where there is not excessive smoke and gas, the walls and ceilings should be kept properly whitened with paint or whitewash. It has been demonstrated that in departments where the walls are whitened the natural and artificial light is increased about 20 per cent. It also adds materially to the natural light to keep the windows clean.

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